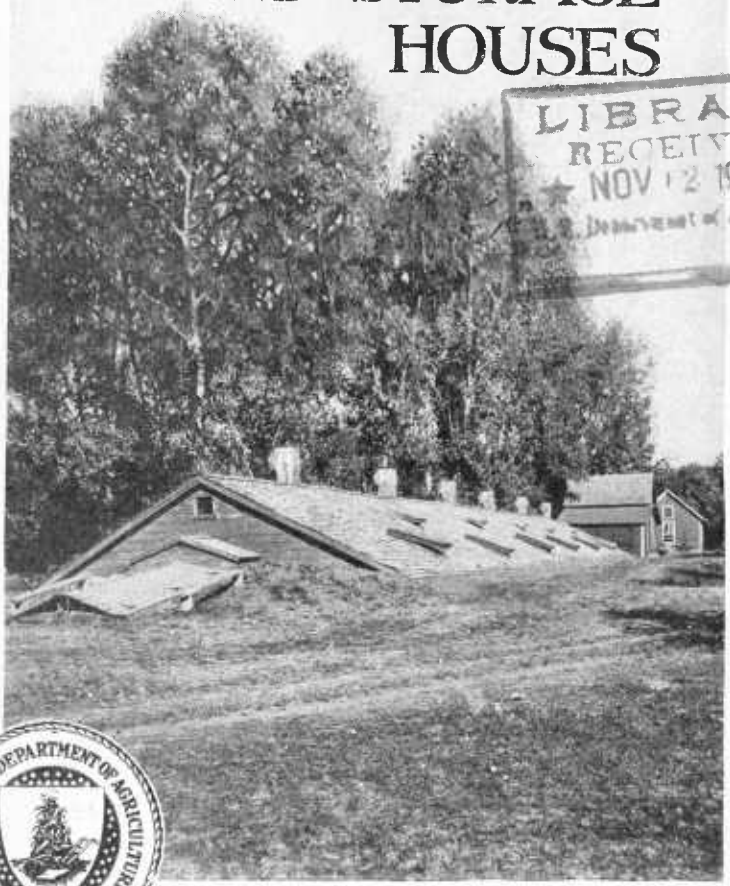
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 847 rev. July 1924

Rev. ed. follows

POTATO STORAGE AND STORAGE HOUSES



POTATOES are among the most important food crops in the United States, and storage has necessarily been utilized to a very considerable extent to hold over supplies for both seed and food purposes from one season to another.

When potatoes were plentiful and relatively cheap, little attention was given to such wastage and loss as usually occur in storage; in fact, a considerable loss was considered inevitable. With high prices and scarcity of supply the need of conserving the entire production for seed and food purposes is of the utmost importance.

Potato storage serves two purposes, the first of which is to make possible a longer marketing period for the crop, and the second, to insure the minimum amount of loss from moisture and decay.

The successful storage of potatoes is dependent on a number of factors; as, for example, the quality of the tubers stored, the temperature at which they are held, the moisture content of the air, the size of the storage pile, and the exclusion of light. The proper storage temperature for potatoes is supposed to range from 34° to 38° F.

Careful investigations during several seasons have clearly demonstrated that losses in storage can be largely prevented by the proper construction and intelligent management of storage houses.

This bulletin deals with the fundamental factors of construction and management of storage houses, as well as the methods of handling the crop that govern the condition of potatoes in storage.

Washington, D. C. Issued July, 1917; revised July, 1924

POTATO STORAGE AND STORAGE HOUSES.

By WILLIAM STUART, *Horticulturist, Office of Horticultural Investigations, Bureau of Plant Industry.*

CONTENTS.

POTATO STORAGE.

THE comparative ease with which potatoes are ordinarily carried through the winter in the northern portion of the United States is very largely responsible for the fact that little, if any, accurate experimental evidence is available regarding the conditions under which potatoes for seed and food should be stored for the best results. The quantity of potatoes annually stored is relatively large, but thus far very little is known regarding the actual losses from shrinkage and decay sustained under different storage conditions.

THE OBJECT OF STORAGE.

The primary object of storage is to hold a more or less perishable fruit or vegetable product in a salable condition throughout as long a period as may be economically desirable. In the case of the potato it is with the late or main-crop varieties, intended for winter use, that the problems of storage arise, the early or truck crop being disposed of direct from the field as harvested.

Storage not only serves to hold perishable crops in a salable condition, but insures also a more uniform market supply throughout the season.

The factors supplied by storage must be of such a character as to protect the tubers from extremes of cold and heat and from the light. Usually these are the only matters seriously considered in storage construction. It is believed, however, that when accurate data are available, humidity, aeration, and the size of the storage pile or bin will be found to be rather important factors.

STORAGE TEMPERATURES.

Various notions are current regarding the best temperature at which to store potatoes, but the subject has not yet received careful experimental investigation, particularly with respect to seed stock.

NOTE.—The investigations upon which this bulletin is based were made in the potato investigations of the Office of Horticultural Investigations in the Bureau of Plant Industry. The fruit and vegetable handling, transportation, and storage investigations of the Department of Agriculture are now prosecuted jointly and cooperatively by the Bureau of Plant Industry and the Bureau of Agricultural Economics.

The temperatures which are generally recommended by those who have written upon the subject of potato storage vary from 32° to 45° F. Most writers, however, recommend a temperature of 33° to 36° F.

Careful investigations have shown that the freezing point of the potato is between 29° and 28° F.

When it is remembered that the sole function of storage is to preserve the stored product in as nearly its original condition as possible, it would seem that the maximum temperature at which tubers can be maintained firm and ungerminated and at the same time hold fungous diseases in check should be considered the most advantageous, whether it be 32°, 34°, 36°, or 40° F., or even higher. Our present belief, based upon the last seven years' experience with an artificially refrigerated potato storage room, is that a temperature of about 36° F. is sufficiently low for all practical purposes and that in the earlier portion of the storage season a temperature of 40° F. is probably just as satisfactory as a lower one except where powdery dry-rot infection occurs.[1]

Every effort should be made to reduce the temperature of the storage house as quickly as possible after the potatoes are stored. This may be accomplished by opening doors, ventilators, and windows on cool nights and closing them early in the morning.

THE EFFECT OF STORAGE FACTORS.

A clear understanding of the effect of storage factors upon the life processes and the quality of the product in storage is vital to their

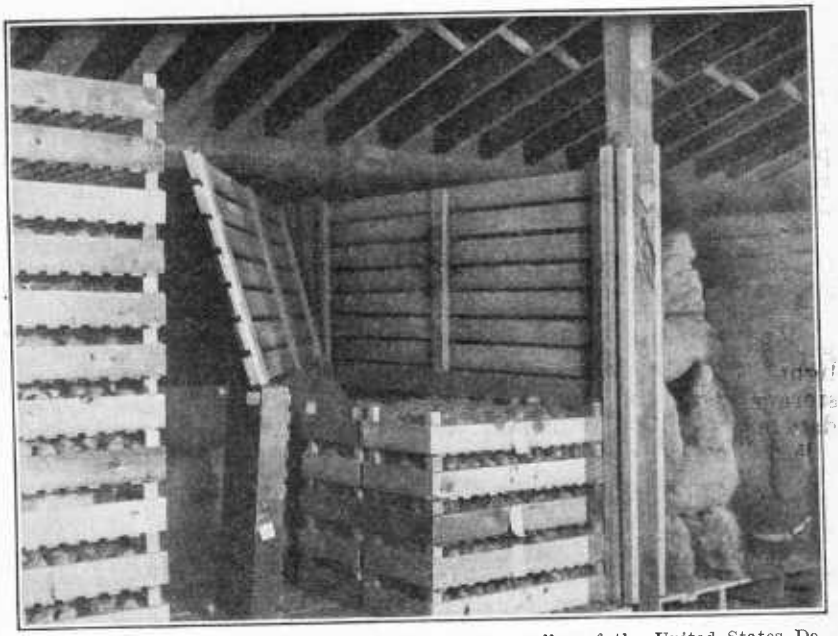


FIG. 1.—Interior view of the former potato storage cellar of the United States Department of Agriculture at Jerome, Idaho, showing the ventilated division walls and floor and the slat-bottomed flats for storing seed potatoes.

[1] Recent investigations by the Department of Agriculture have demonstrated that the powdery dry-rot is most effectively held in check at a temperature of 34° to 35° F.

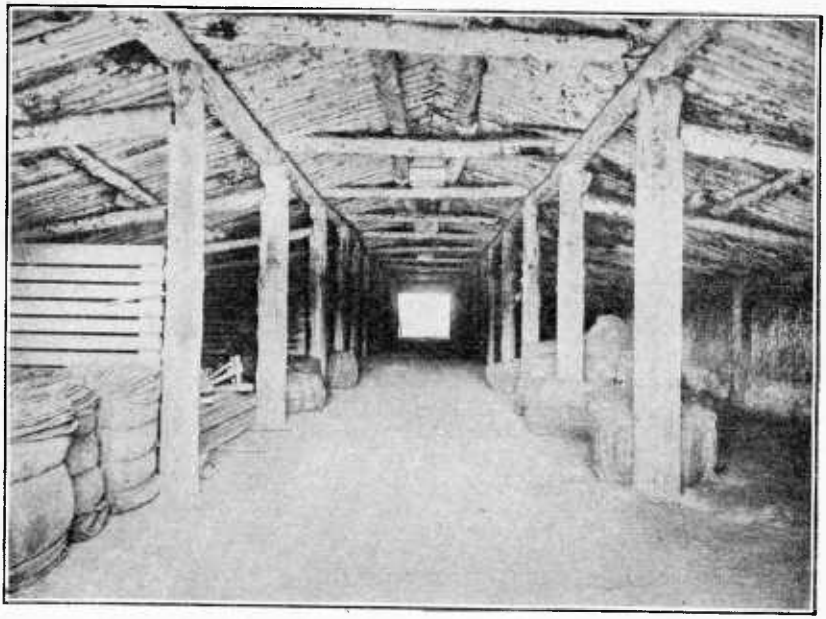


FIG. 2.—Interior view of a potato storage cellar on the Sweet Seed Farms, Inc., Carbondale, Colo., showing ventilated division wall, pole roof, and supporting timbers. (Courtesy of L. D. and F. E. Sweet.)

intelligent use. In the discussion of these factors, therefore, an attempt will be made to explain the effect of temperature, light, humidity, aeration, and size of pile or bin upon the stored product.

THE EFFECT OF LOW STORAGE TEMPERATURES.

It has long been recognized that when potato tubers have been subjected to a temperature of about 32° F. for any considerable period, the flesh when cooked has a decidedly sweetish taste. This may or may not be an objectionable feature, according to whether or not the tubers are to be used for table purposes immediately upon removal from storage. Some rather recent studies by one investigator [2] have served to demonstrate that when such tubers are exposed to a temperature of 70° to 75° F. for a week, about four-fifths of the sugar accumulation is removed. It is therefore apparent that while any considerable sugar accumulation in the potato is not desirable it does not constitute a permanent injury for table purposes.

LIGHT.

Potatoes when exposed to strong or even modified light are soon materially injured for food purposes. It is therefore necessary, in order to preserve the table quality of a potato, to exclude all light from the storage house. Exposure to modified light, if the potatoes are kept cool and well aired, is not injurious to tubers intended for seed purposes. Wherever it is feasible the storage house should be lighted by electricity.

[2] Appleman, C. O. Changes in Irish potatoes during storage. Md. Agr. Exp. Sta. Bul. 167, p. 330. 1912.

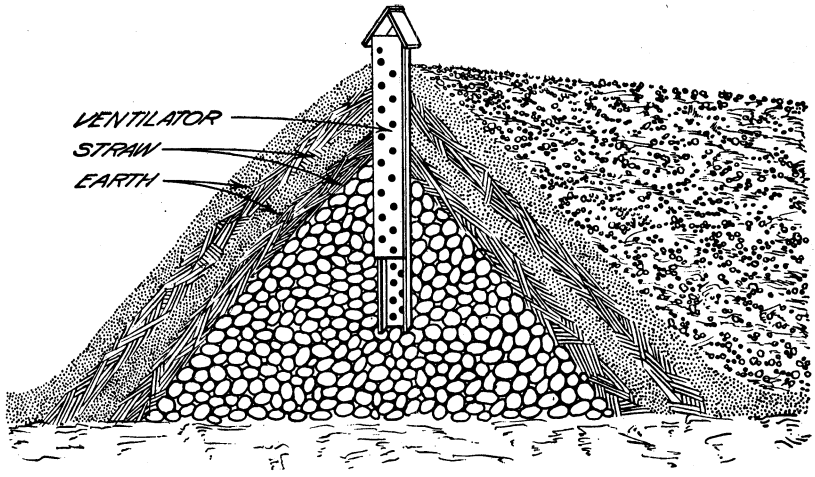


FIG. 3.—Cross section of a potato pit insulated with layers of straw and earth, showing the perforated ventilator in position and the potatoes piled in inverted V-shaped fashion.

HUMIDITY.

Little accurate information is available relative to the proper amount of moisture to maintain in the air of the storage house or room. Whether the moisture content of the air should be high or low is a question which we are not yet prepared to answer. In the storage house of the Department of Agriculture the object has been to maintain sufficient moisture in the air to prevent the wilting of the tubers and at the same time keep the humidity content low enough to prevent a deposit of moisture on the surface of the tuber. One investigator [3] suggests a humidity of from 85 to 90 per cent as about correct for a potato storage room temperature of 33° to 35° F.

AERATION.

Recent studies at the Marble Laboratory,[4] Canton, Pa., indicate a wide difference in humidity content of air immediately surrounding the tubers in the bin and air in the storage house. This observation is important in that it serves to emphasize the necessity of providing adequate facilities for ventilation and aeration of the potato bin. Storage rots and surface molds can be successfully held in check only when the skin of the tuber is kept dry.

In order to insure an ample supply of pure air in the storage house it is necessary to make generous provision for ventilation. The ventilators or air flues should be so arranged as to insure a rapid and even distribution of air throughout the structure. The value of pure air to the stored tubers, particularly those intended for seed purposes, has not been investigated experimentally as yet, but it can hardly be other than beneficial. The European grower finds it advantageous to store seed potatoes in open crates or shallow trays, thereby insuring

[3] Cooper, Madison. Practical Cold Storage, ed. 2, p. 503. Chicago, 1914.
[4] Marble, L. M. Potato storage investigations during 1922-23. *In* Proc. 10th Ann. Meeting Potato Assoc. America, 1923. (In press.)

a free circulation of air around the tubers. Other methods for securing good aeration in storage will be brought out in the discussion on construction.

SIZE OF STORAGE PILE OR BIN.

It is a bad practice to store potatoes in large bins or piles. Not infrequently potatoes are piled to a depth of 10 to 15 feet, the pile being correspondingly large in the other two dimensions. When stored in this manner they are almost certain to go through a rather violent sweating or curing process, during the course of which the tubers in the central portion of the pile are frequently subjected to a dangerously high temperature. This is especially true if the tubers are slightly immature, or were not dry and free from moist soil when gathered, or if stored when the outside temperature is high, making it difficult to lower the inside temperature of the house. Overheating from all of the causes mentioned may be avoided by making some provision for aerating the pile. This is most easily accomplished by inserting ventilated division walls at intervals throughout the pile. The division walls may consist of 2 by 4 inch uprights on the 2-inch face of which are nailed seven-eighths by 4 inch strips of any desired length, laying a 1-inch space between each strip. This gives a ventilated partition, which can be of any height and length desired. By placing these in an upright position 5 to 6 feet apart as the bin or storage house is being filled, good ventilation will be secured and an easy avenue of escape for both heat and moisture provided, thereby lessening any danger from overheating or from the spread of injurious fungous diseases. Ventilated division walls of this type were used in the potato storage house of the Department of Agriculture at the Jerome station, Jerome, Idaho, and by a grower at Carbondale, Colo. (Figs. 1 and 2.)

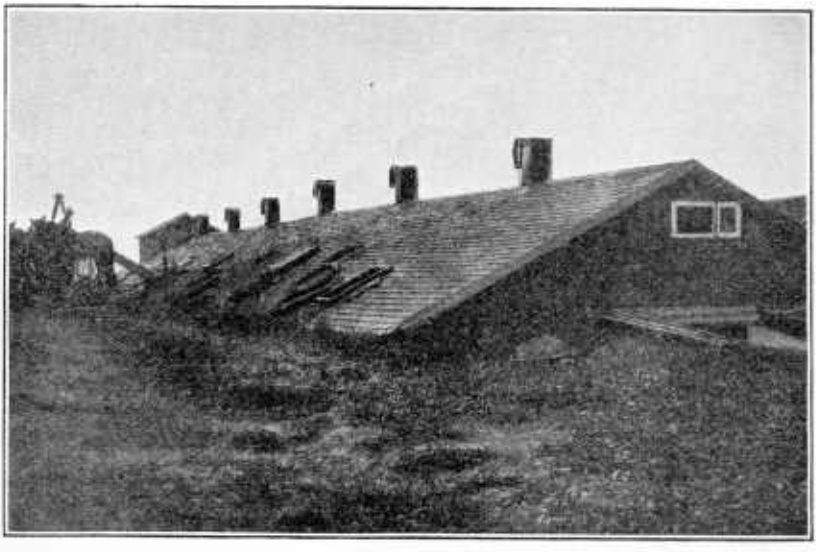


FIG. 4.—A potato storage cellar with water-tight roof, showing openings in the roof through which the tubers are spouted into the cellar. Sabin, Minn.

In storing potatoes the desirability of good aeration should be kept in mind and the necessary provision made for insuring it. It is poor policy to invite heavy storage losses by failure to provide the proper conditions.

TYPES OF STORAGE.

Storage in its primitive stage consisted in burying in the soil the product to be preserved or storing it in a cave or an excavated chamber of some sort. As wealth increased and agricultural industries expanded, more expensive but better types of storage were developed, until to-day we have large, artificially refrigerated cold-storage plants in which the temperature of the various chambers can be maintained at any degree desired.

In the case of the potato, the simplest and most primitive form of storage is still practiced to a limited extent in some sections. While the house cellar is used occasionally for potato storage, its consideration in this bulletin is regarded as superfluous. At the present time the types of storage may be designated as follows:

Pitting.
The dugout pit or potato storage cellar.
The insulated wooden structure.
The Aroostook (Me.) type of storage house.
The artificially refrigerated potato storage house.

In considering the type of storage best suited to one's needs the following factors should be considered: (1) The temperature and

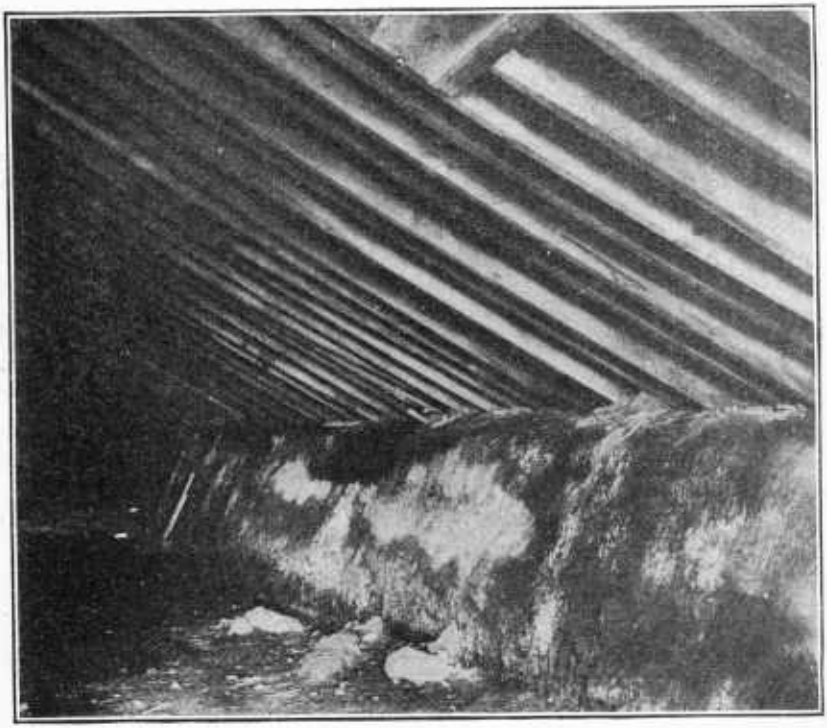


FIG. 5.—A cheap type of potato storage cellar with banks of earth serving as side and end walls, used in semiarid or irrigated sections. Greeley, Colo.

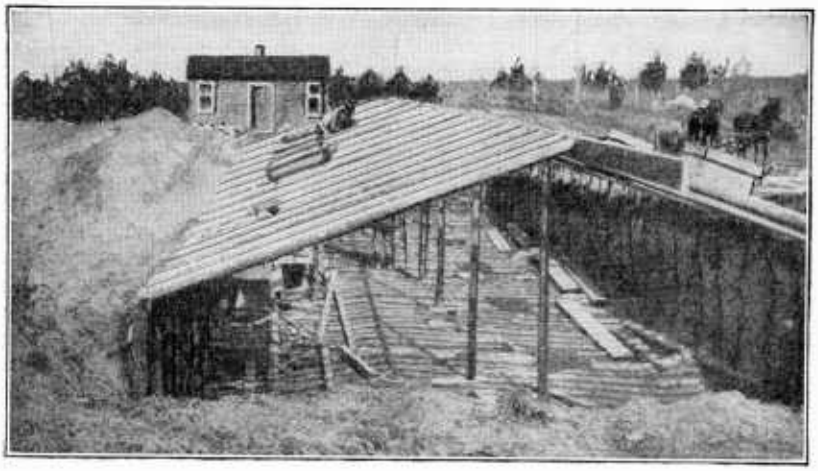


FIG. 6.—A potato storage house in course of construction, showing posts recessed in walls of earth and the method of placing ventilators in the roof. Jerome, Idaho.

precipitation likely to occur during the storage period, (2) the character and cost of material involved, (3) the nature of the soil and drainage, and (4) the storage period.

It is self-evident that in the arid and semiarid regions of the West a materially different type of construction from that in use in the rain-belt section of the East might be desirable.

POTATO STORAGE-HOUSE CONSTRUCTION.

In considering the construction of potato storage houses no attempt will be made to go into minute details regarding the actual erection operations except as they relate to a method to be adopted for insuring good aeration of the stored tubers. It is hoped, however, that the various illustrations of plans and types of storage houses presented will suffice to convey the information necessary to a proper understanding of the essential features of construction of each type discussed.

PITTING.

Potatoes may be successfully stored in pits if provided with good drainage and given sufficient covering to insulate them against external heat and cold. The first consideration is a well-drained site or one which can easily be provided with good drainage.

The depth of the excavation may vary from practically nothing to 2 feet or more. It is usually not advisable to excavate more than 6 inches. The shape of the pit should be long and narrow rather than square.

The size is dependent to a certain extent on the quantity to be stored. It is not advisable to store too large a quantity in one pit, just as it is inadvisable to store too large a quantity in a bin or house.

In preparing the pit for the reception of the potatoes it is desirable to place a light layer of straw on the floor to protect the tubers from direct contact with the soil. The tubers should be piled in a ridge of inverted V shape, as shown in Figure 3. When piled in this way a

greater area of the pile is exposed to the air, and at the same time when covered it sheds rain much better. Before covering the pile, or, in fact, before the potatoes are piled, it is desirable to make some provision for ventilation to take care of the moisture given off in respiration.

The potatoes are best insulated against cold and heat by covering with alternate layers of straw or hay and soil. The first layer should consist of straw, adding only sufficient soil to prevent injury to the tubers from exposure to light or frost. The object is to cool off the tubers and as soon as possible to get rid of the moisture resulting from the sweating process. As the weather grows colder more straw should be added and then a layer of soil. With the approach of winter weather another heavy layer of straw should be put on and an additional layer of soil. The two layers of straw and the soil are usually a sufficient protection, but in sections where the winter temperatures drop to 20° F. or more below zero an extra layer of each will be necessary. Each layer of straw when compacted should be approximately 6 inches thick. The final layer of soil may be 6 to 8 inches deep, depending upon the amount of rain and snow likely to fall during the storage period.

Ventilation may be provided by means of a wooden flue, the lower end of which extends almost to the bottom of the pit, while the upper end projects well above the covering, as shown in Figure 3. The ventilating flue should be provided with a wooden cap to prevent the entrance of rain or snow, but at the same time it should be so

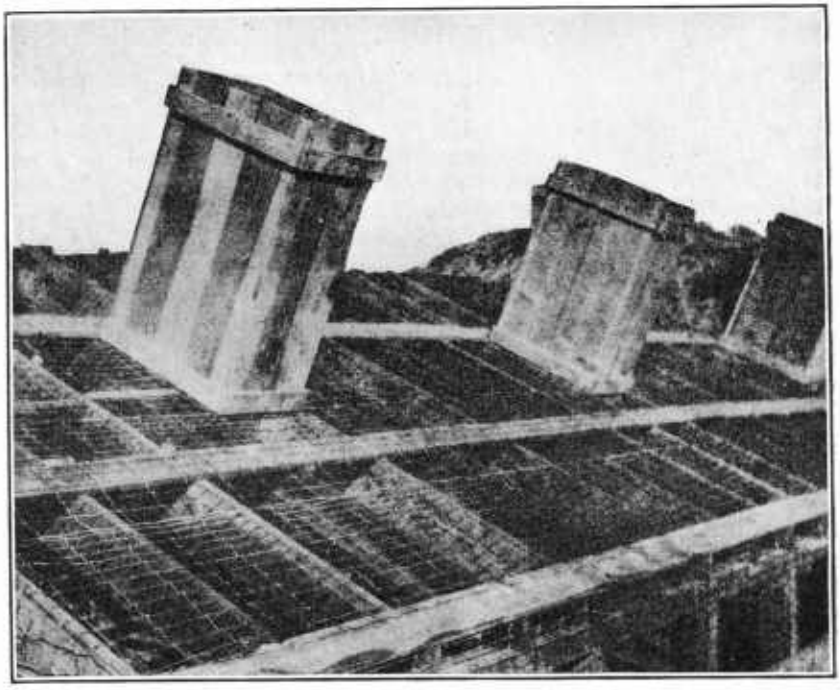


FIG. 7.—A potato storage cellar, showing side and roof framing covered with woven wire and with ventilators in place, ready for applying the layers of straw and earth. Aberdeen, Idaho.

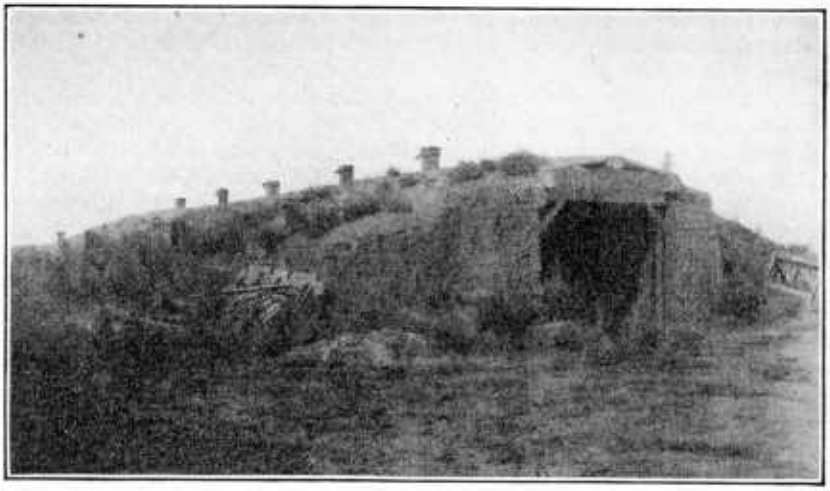


FIG. 8.—A potato storage house with walls of sod, adapted only to dry sections.

constructed that it can be closed entirely during extremely cold weather. If the required attention be given to the preparation and protection of a pit of this sort, one can be reasonably certain that the tubers will keep in almost perfect condition until spring. The objection to the pit is that the potatoes stored therein are not always accessible during the winter.

THE DUGOUT PIT OR POTATO STORAGE CELLAR.

The dugout pit or potato cellar in some of its various forms of construction is probably more widely used than any other type of storage space. In the central and western portions of the United States it is practically the only kind of storage employed. It is found in its most primitive state in the arid and semiarid regions of the West, where the low rainfall makes a water-tight roof unnecessary. As a rule, the excavation for the cheaper structures of the dugout pit or cellar type when erected on level or nearly level land does not exceed 3 feet. The soil removed from such an excavation, particularly if the dugout is of any considerable size, is ample for banking the side and end walls and also for the roof. The cost of construction may be greatly modified, according to the character of the location.

Generally speaking, the potato cellar should be located convenient to the dwelling house, because in very cold weather it usually requires rather close attention to guard against having the tubers frosted. Where sidehills, knolls, or what are termed in the West "hogbacks," consisting of narrow and usually short ridges of land, are available, it is advisable to take advantage of them, because as a rule by their use better drainage and a ground-level entrance at either one or both ends of the house are secured. Where sidehills, knolls, or hogbacks are not available and a central driveway is planned, an inclined drive, which should be carried back far enough to permit easy approach, is necessary. Where no wagon entrance is contemplated, provision is usually made for placing the potatoes in the cellar through openings in the roof, in which chutes are inserted to

convey the tubers (fig. 4). In this type of storage house a bulkhead entrance is provided in order to permit easy access for the removal of the stored crop.

In the cheaper dugouts, where the soil is of such a nature as to remain intact it is allowed to form the side and end walls, the roof being supported on plates resting on the soil and held together by boards or joists (fig. 5). This form of construction involves a deeper excavation and a constant element of risk from a cave-in. A better type of construction is represented in Figure 2, in which rough posts are set at intervals along the side walls, and to these the plate is fastened. These posts may be recessed into the wall of earth so as to present an even face (fig. 6), or they may be set out far enough to allow covering them with wire, planking, or poles, and a heavy layer of straw (fig. 7).

Occasionally, where the land is level and there is danger from irrigation seepage, the storage house is built entirely above ground. In this case, while the construction of the side and end walls and roof is practically the same as the preceding, the cost is usually increased on account of the greater quantity of soil required to cover the roof and the side and end walls.

Where a tough sod is available, such as that formed by flags or other wiry rooted plants, the side and end walls above ground may be constructed entirely of blocks of sod 2 feet or more in thickness (fig. 8). One of the most unusual storage houses seen in the course of these studies was built entirely above ground with the side and end walls constructed of baled alfalfa hay.

In the more expensive and substantial structures the side and end walls are built of concrete. The material entering into the roof con-

FIG. 9.—Interior view of a potato storage cellar with side and end walls of stone, showing the type of roof construction adopted. Greeley, Colo.

FIG. 10.—A small potato storage cellar on the eastern shore of Virginia, with a water-tight roof and ground-level entrance. Unless it is well insulated, this particular style of construction is undesirable.

struction of the dugout, or cellar storage house, in the region under discussion generally consists of unsawed lumber. Usually the rafters are cut from small trees (figs. 2, 6, and 9). The whole roof may be covered with poles (fig. 2) and these poles covered with straw and soil, or the rafters may be covered with heavy woven-wire fence netting (figs. 7 and 9) and then with straw and soil.

In sections where the rainfall is sufficiently heavy to render straw or pole-covered roofs undesirable, the potato storage cellar is constructed with a water-tight roof. Generally, the roof is covered with rough lumber and shingled. Occasionally a cellar is sheathed with

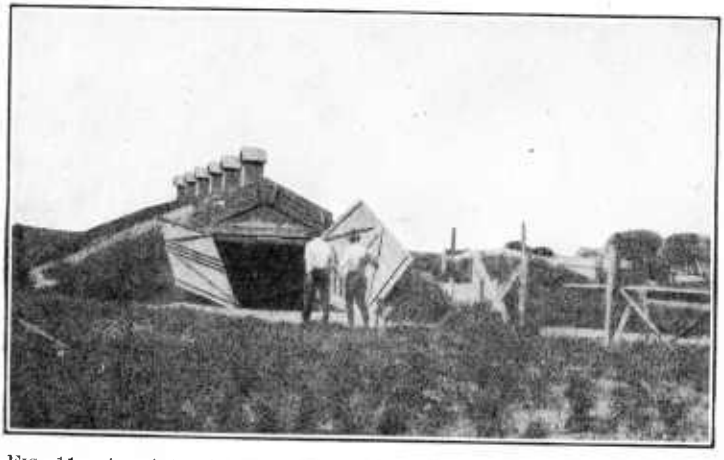


FIG. 11.—A potato storage cellar, showing a bulkhead driveway entrance in which the grade into the cellar is cared for after entering the bulkhead. Jerome, Idaho.

matched lumber on the inside. This treatment provides a fairly well insulated roof, which requires but little further protection except in protracted spells of cold weather, when a layer of straw or strawy manure is advisable.

The water-tight roof type of the western potato cellar is admirably adapted to storage in the northeastern and middle-western United States wherever good drainage can be secured. Furthermore, as mentioned in connection with the cost of construction, it is also one of the most economical types of natural storage. Figures 4 and 10 show potato storage cellars with water-tight roof construction.

Entrance way.—The entrance to the storage cellar, whether for team or man, should be provided with two sets of doors. The vestibule, or bulkhead, entrance is a convenient one and provides good protection against cold or heat (figs. 11 and 12).

Ventilators.—Provision should be made in all dugouts or storage cellars for generous ventilation. Such provision for ventilation is shown in Figures 4, 6, 8, 11, and 12, and in the title-page illustration. Several styles of ventilators are illustrated, and it is largely a question of preference on the part of the builder which type is selected.

A ventilator should be so constructed that the opening at the top is protected by a cap, which may be rigid or hinged. It should extend through the roof into the cellar far enough to permit a swivel damper to be inserted and operated by a spring or lever, or else a slide damper which can be opened or closed at will. The ventilator should be of sufficient size to admit a reasonable volume of cool air and facilitate the egress of warm air.

Lighting.—While the total exclusion of light is an essential feature of the construction of a good potato storage house, it is necessary

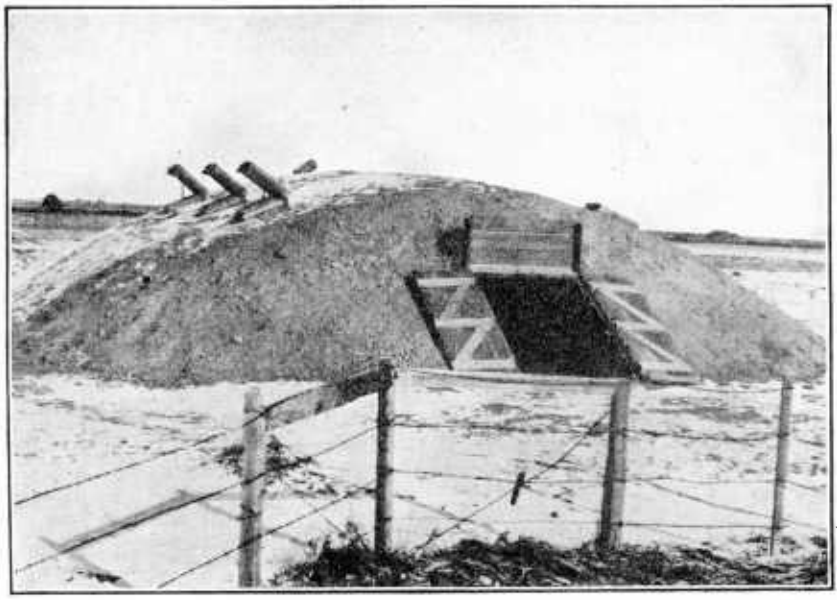


FIG. 12.—The potato storage house shown in Figure 7, with the covering of straw and earth in place. Note the bulkhead entrance and the hinged ventilator caps. (Courtesy of L. C. Aicher.)

where workmen are engaged in sorting and preparing stock for market or for seed purposes during the winter to employ light. Usually no provision is made for lighting the storage house by natural light except that which may filter through the ventilator shafts when lifting the ventilator caps or may be obtained by opening the doors. This method of admitting light can be employed in winter only during mild weather. Light is admitted in some storage houses, and this system could be generally employed, if desired, by inserting a movable window glass or hinged window in the ventilator shaft. Such an arrangement permits the removal of the ventilator cap in severe weather without endangering the stored potatoes by lowering the temperature below the safety point. While such a system of lighting may be adequate for the area of the storage room immediately below the shaft, it does not provide a wholly satisfactory lighting system, and reliance must still be placed in a lantern or lamp. The potato storage houses constructed by the Department of Agriculture are electrically lighted, and wherever electricity is available this method of lighting is urged upon those contemplating

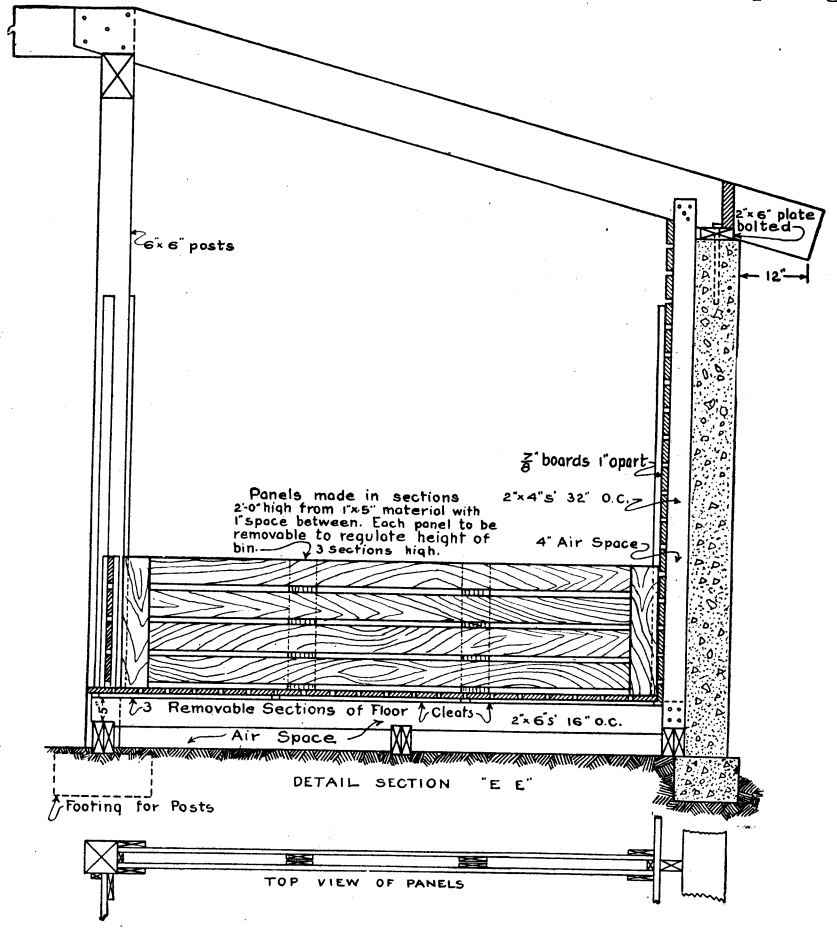


FIG. 13.—Section of one side of a potato storage cellar, showing the method of constructing the aerated bin. Jerome, Idaho.

the erection of such a house. The cost of installation, wiring, and fixtures is comparatively light, and the actual necessary amount of electric current consumed during the storage season is very small. The advantage derived from the possession of an electrically lighted storage house is out of all proportion to its cost.

A full description of the materials entering into the construction of some of the better grade dugouts will be found in the accompanying plans prepared for the erection of a storage cellar on the Sweet ranch, at Carbondale, Colo., and in those prepared for the potato storage cellar at Jerome, Idaho. (Figs. 13 and 14; see also figs. 19 and 20.)

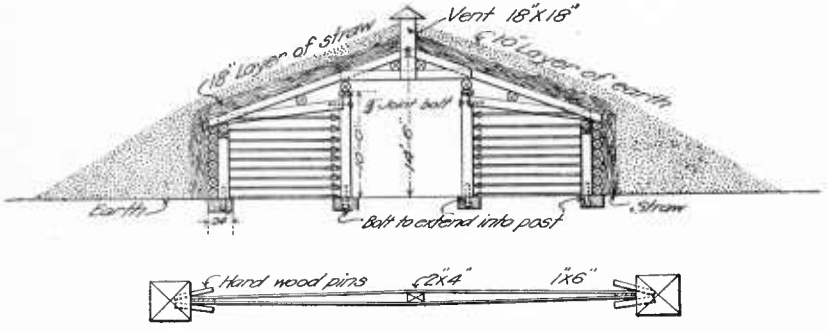


FIG. 14.—Cross section of the end elevation of the potato storage cellar on the Sweet Seed Farms, Inc., Carbondale, Colo.

Interior arrangement.—The interior arrangement of the storage cellar is governed very largely by the size and character of the structure. Where no driveway entrance is provided and the house is narrow, say 12 to 20 feet wide, the entire space is used for storage purposes. The dirt floor of the cellar may be left uncovered or it may be floored over with rough lumber; in some cases it is cemented.

In some of the better types of houses in which there is a central driveway with bins on either side, the driveway is an earthen one, but the storage bins have ventilated wooden floors laid on joists. The joists, being at right angles to the drive, provide an open space between the floor and the earth beneath, and this, as will be seen later, furnishes an unrestricted circulation of air beneath the bin (fig. 1). Where posts are used in the construction of the side and end walls and these are covered with woven wire on their outer surface, the inner surface of the posts should be covered with 3-inch board strips, allowing a 1-inch space between the

FIG. 15.—An insulated frame potato storage house used for storing second-crop potatoes. Morrill, Tex.

boards. This type of construction provides a conduit for air on the side wall and, connecting with the bottom, affords an air passageway completely around the stored tubers. In storage cellars having an interior width of 30 feet and a length of 50 to 100 feet with a central driveway, the following arrangement seems to be both suitable and practicable. The driveway need not be over 9 to 10 feet in width and the side bins 10 feet in length and 10 to 11 feet in depth, depending on whether the driveway is 9 or 10 feet in width. These units of length seem desirable, because this is a convenient distance at which to set the purlin supports.

The division walls may be constructed after plans shown in Figure 13 or they may follow those shown in Figure 14. In any event the division walls should be double, with an air space between, and the partitions should be constructed with air spaces between the boards. The front wall of the bin is constructed in sections similar to those of the partition walls, but it is only a single wall. This type of bin construction very materially lessens the danger from tuber heating in storage and provides a convenient and sanitary bin which can be taken down easily and disinfected when desired.

THE INSULATED FRAME STRUCTURE.

The insulated frame potato storage house is not used very extensively and as a rule is better adapted to southern than to northern climatic conditions. The construction feature of such a storage house is the thorough insulation of its walls, ceiling, doors, and windows (figs. 15 and 16). The type of house described in Farmers' Bulletin 970, Sweet-Potato Storage, will serve equally well for the potato, but in the case of the latter no artificial heat will be required. Facilities for heating storage houses of the type under discussion, in the North at least, must be provided for extremely cold weather. This is usually accomplished by means of an ordinary heating stove. This type of storage house is not to be recommended for northern locations, nor is it advocated for the South except where poor drainage conditions will not permit the use of the dugout or cellar style of house. It is not recommended, because it can not be so economically constructed, nor does it furnish as good a type of storage as the properly ventilated cellar storage house.

THE AROOSTOOK TYPE OF STORAGE HOUSE.

The Aroostook type of storage house, with concrete or masonry basement walls and wooden superstructure, seems to be distinctively a product of Maine, and so far as has been observed is not found to any extent outside of that State. It is an expensively constructed house and is almost always located on a sidehill or knoll in order that advantage may be taken of a ground-level entrance. Few, if any, of these storage houses have both front and rear end driveway entrances on the same ground level, but practically all of them have a rear ground-level basement driveway and a front ground-level entrance to the wooden superstructure. When the rear entrance is located in the end (fig. 17), the basement is usually divided into a number of bins on either side of the driveway. The floor may or may not be of cement. Usually those storage houses that have a cement floor, as well as those which have not, are provided with wooden floors somewhat similar in construction to those shown in Figure 1.

The basements of the Maine type of storage house are usually from 8 to 12 feet in depth, and most of them have a capacity of several thousand barrels. As a rule, the only provision for the ventilation of the basement is by means of trapdoors in the floor above, through which the filling of the bins is completed. Occasionally a ventilator is found in the roof. In storing the potato crop in the basement the bins are filled from one-half to two-thirds full from the basement floor, and, as already stated, the remainder of the bin is filled from the upper floor through a trapdoor over each bin. In addition to serving a useful purpose in filling the bins and protecting the potatoes from inclement weather, the wooden superstructure of these storage houses may be used for the housing of hay or grain or for barrels, sacks, farm implements, and wagons. The house shown in Figure 17 is representative of this type and gives a fairly accurate conception of the style of construction of its exterior. That such houses have proved satisfactory to the potato grower in Maine is evident from the fact that practically no other style of potato storage house is in use in that State. It is not conceivable, however, that they will ever supersede the dugout pit or storage cellar now so extensively used in the Middle and Far Western States, and it is not at all probable that the latter will ever supersede the Aroostook type in Maine. Both have distinctive features which peculiarly adapt them to their own environment but do not necessarily preclude their use in other localities.

THE ARTIFICIALLY REFRIGERATED STORAGE HOUSE.

The artificially refrigerated potato storage house is as yet hardly in existence. The present use of this type of storage house is confined practically to the holding of northern-grown seed potatoes in cold storage for second-crop planting in the South.

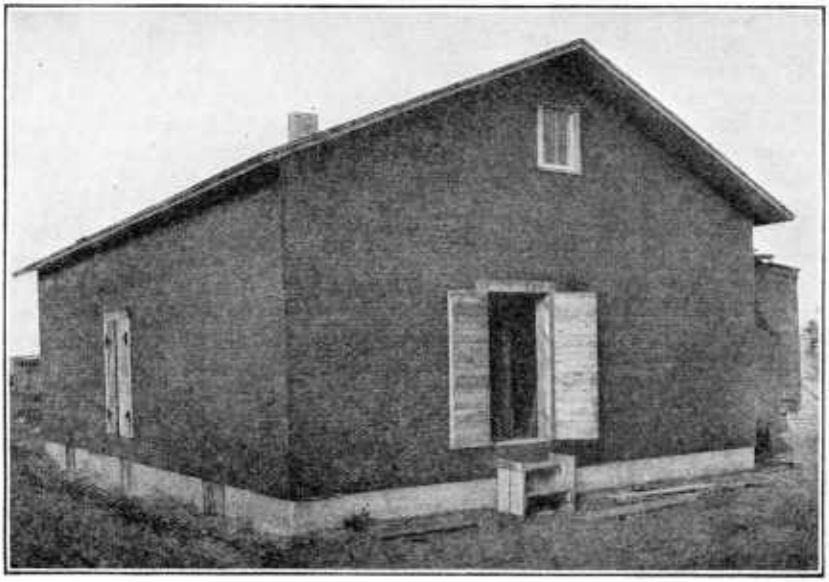


FIG. 16.—An insulated frame potato storage house with a basement cellar. Greenville, Mich.

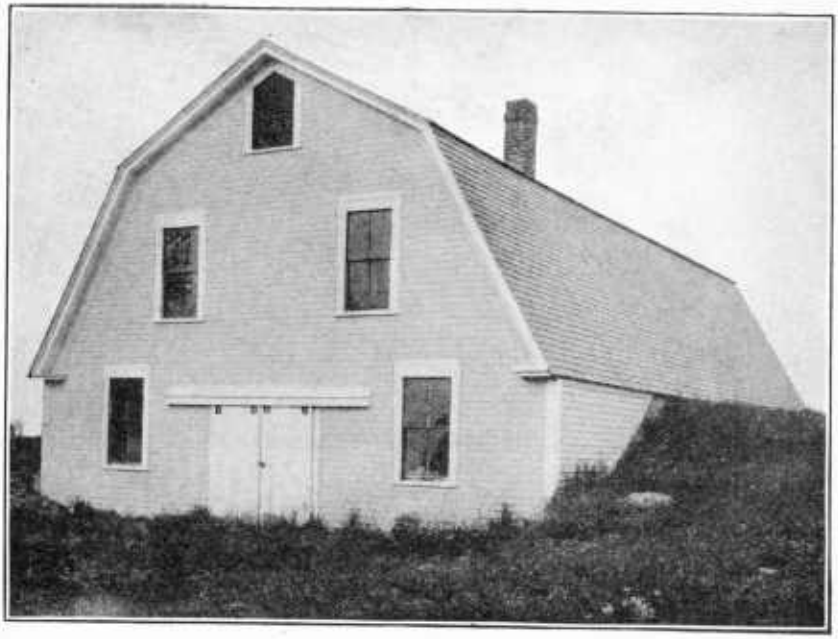


FIG. 17.—A potato storage house in Maine, showing a central driveway entrance into the lower or basement portion. The end entrance is more commonly used, especially in the larger structures, than is the side entrance at one end of the building.

There is probably little demand for an artificially refrigerated potato storage house in the northern potato-growing sections of the United States, but it is a debatable point whether community cold-storage plants could not be profitably employed by the southern truck growers. At the present time practically all of the northern-grown seed used by the southern grower is shipped to the South during the months of November, December, and January, depending upon the locality to which it is consigned. As a rule, the seed stock is in transit from the North during dangerously cold weather, and it must be accompanied by a person charged with the responsibility of keeping it from freezing. Artificial heat is supplied to the car by means of stoves, and they often require more attention between stopping points than it is possible to give them, with the result that the car gets overheated or too cold, either of which conditions is undesirable for seed potatoes. If, on the other hand, the southern grower had suitable storage facilities he could purchase his supply of seed in the fall and have it delivered before cold weather sets in. It could then be placed in cold storage or in a well-constructed house of the cellar-pit style with a water-tight roof provided with numerous ventilators for the free admission of air when the outside temperature permits. This practice would remove very materially the present objection of the truckers to purchasing their seed supply subject to fall delivery, because under good storage conditions the seed could be easily kept dormant until required for planting. Such a change would also enable the grower to buy his seed for less money than for mid-winter delivery.

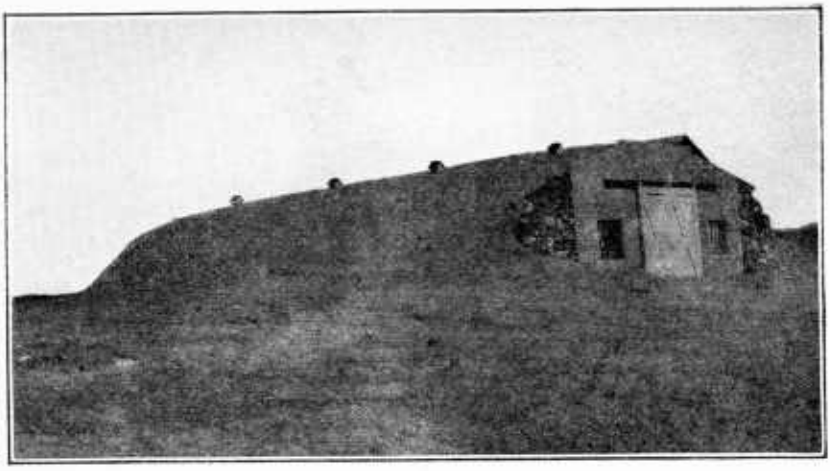


FIG. 18.—Former potato storage cellar of the Department of Agriculture at Jerome, Idaho, showing the end entrance and the arrangement of the ventilators.

The temperature at which the storage rooms for seed potatoes are usually held is maintained at from 32° to 34° F. It is believed, however, that 34° to 38° F. would be a more satisfactory temperature.

For several seasons the gravity brine system of refrigeration has been used in the potato storage room of the Department of Agriculture. With this system, in which ice and salt are used as a substitute for ammonia or carbon dioxid in cooling the brine, the maintenance of a constant temperature is entirely dependent upon the thoroughness with which the surrounding walls, ceiling, and floor have been insulated and the attention given to reicing the coil tank and to observing that the brine in the circulating coils is actually circulating. The temperature can be raised or lowered by simply varying the proportions of ice and salt used in the tank. Temperature records covering a week's time have frequently been secured in which there was practically no variation during the whole period. With this system it has been possible to keep seed potatoes perfectly dormant until wanted for planting.

COST OF CONSTRUCTION.

Owing to the wide variation in the cost of building material and in the price of labor in different sections of our country, the discussion of the cost of constructing any particular type of house must of necessity be more or less general in its character.

The type and the size of the house are in a large measure determined by the character of material available, the climatic conditions, and the storage capacity required. In determining the size of the storage cellar required to house a given quantity of tubers, the estimate should be based on 40 pounds of tubers for each cubic foot of actual storage space, remembering, of course, that potato tubers should not be stored at too great a depth. Thus figured, a storage bin 10 by 10 feet, filled with tubers to a depth of 6 feet, would hold 400 bushels, or an average of 4 bushels to each square foot of floor space occupied.

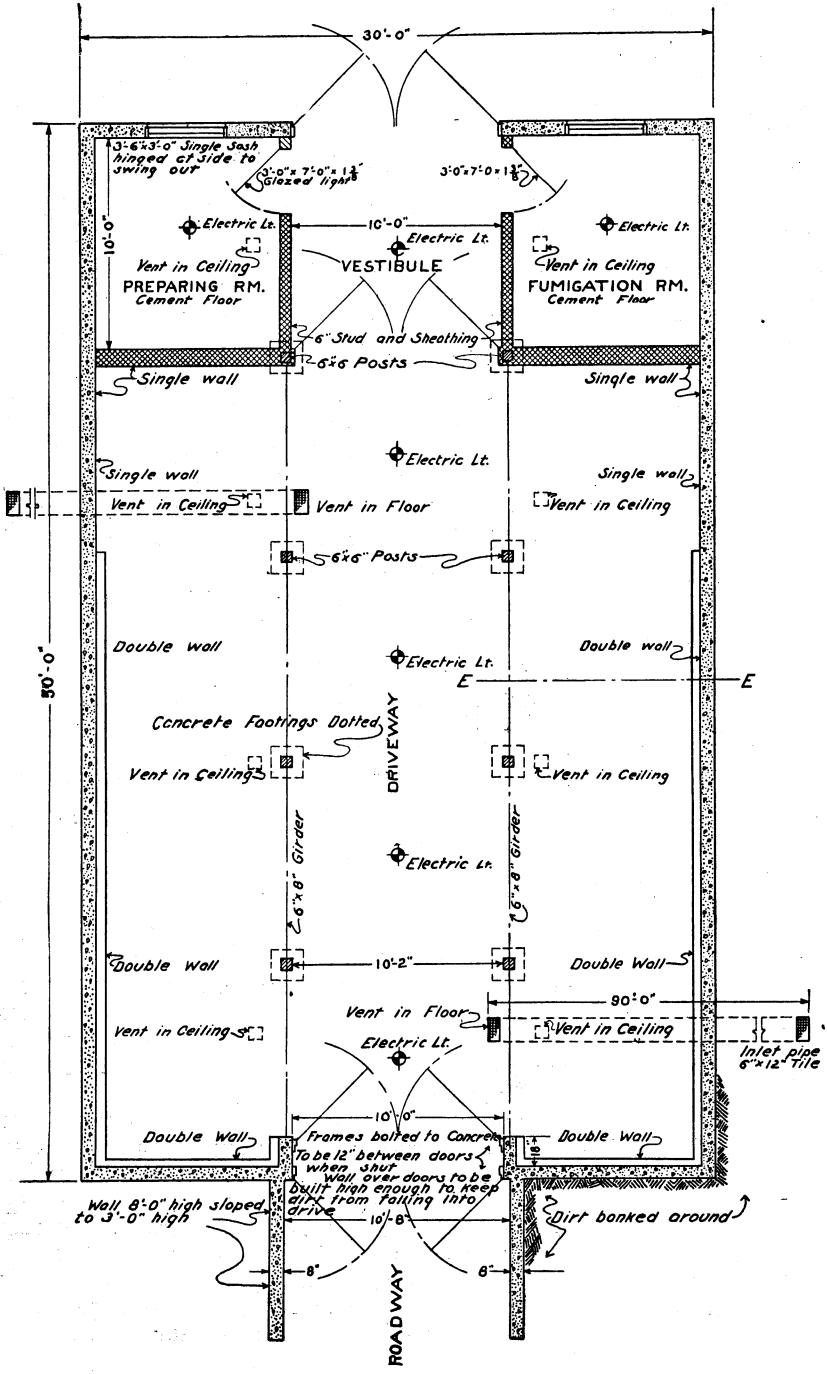


FIG. 19.—Ground plan of the potato storage cellar at Jerome, Idaho.

In order to give the reader some idea as to the relative cost of constructing the various types of potato storage houses previously described, an effort has been made to secure some data from practical potato growers who have erected storage houses or cellars of their own. It is hoped that the suggestions presented contain information which will prove helpful to those contemplating the erection of similar structures.

The first data presented are those obtained from Carbondale, Colo., and relate to the potato storage cellar shown in Figure 2. The capacity of this cellar is stated to be from 13,000 to 25,000 bushels, depending on the depth to which it is filled with tubers. The cost of this cellar is estimated at $1,000, but the Messrs. Sweet state that this does not include the cost of the lumber aside from hauling it. The figure given does not, therefore, represent the actual cost of the building. It would seem that at least $300 might safely be added to the first cost, thereby raising the original figure to $1,300. On this basis the initial cost of providing storage for 1 bushel of potatoes ranges from 10 to 5.2 cents a bushel, depending on the depth to which the tubers are piled. Assuming, however, that the average

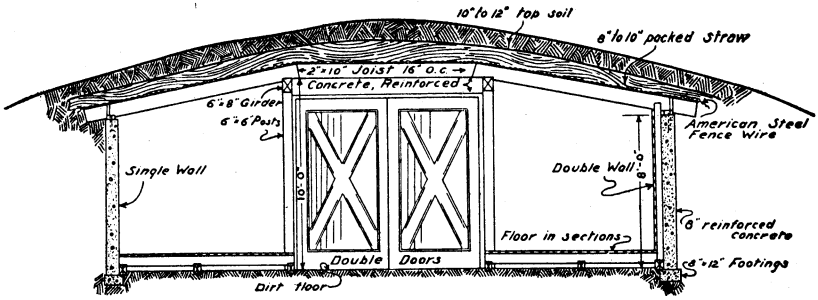


FIG. 20.—Cross section of the end elevation of the potato storage cellar at Jerome, Idaho.

life of a potato storage cellar is about 10 years, the actual storage cost is reduced to 1 cent and fifty-two one-hundredths of a cent per bushel, respectively. These figures are somewhat lower than those presented by some investigators,[5] who state that the first cost of storage in an average grade of potato cellar is about 20 cents a hundredweight, or 1.2 cents per bushel a year on a 10-year basis. They further state that the first cost of storage in a cellar constructed without much regard to permanence and by the utilization of farm labor might be as low as 7 cents per hundredweight.

A Minnesota grower submits the following data relative to his potato cellar, which was constructed with wooden walls and watertight roof, as shown in Figure 4: The size of the house is 20 by 100 feet, 4½ feet below ground and 4 feet above ground, with a storage capacity of 12,000 bushels piled 8 feet deep. Figuring the storage capacity of this house on the basis of 40 pounds per cubic foot of tubers, it is found that the actual content is about 10,666 bushels. This house was constructed at a cost of $1,200, or an average initial cost of 11.25 cents per bushel or of 1.125 cents a year on a 10-year basis.

[5] Fitch, C. L., and Bennett, E. R. The potato industry of Colorado. Colo. Agr. Exp. Sta. Bul. 175, p. 47. 1910.

The storage cellar shown in Figure 4 is provided with ventilators in the roof every 10 feet and has two lines of openings in the roof for the admission of potatoes. It does not have a driveway entrance, but is provided with bulkhead entrances at each end. The roof is protected from severe cold by a covering of straw or strawy manure. The inside temperature during such periods is taken by lowering thermometers, suspended by strings, through the ventilator shafts. The comments of the owner regarding this type of house are that the walls should be made of concrete or stone and should be 8 to 10 inches thick. Such construction, he believes, is cheaper in the end, as the walls are practically indestructible, whereas the wooden ones quickly rot out.

A Caribou (Me.) grower submits data regarding the construction of a potato storage house of the Maine type having dimensions of 40 by 60 feet and a storage capacity of 4,500 to 5,500 bushels at a cost of $3,500, or an initial cost of from 64 to 82 cents per bushel. He further states that the same house could be built without a concrete cellar, but resting on concrete piers, for $2,500 to $2,700. According to his statement, the more common size for smaller houses is either 35 by 60 feet or 40 by 50 feet.

In the fall of 1914 the Office of Horticultural and Pomological Investigations of the Bureau of Plant Industry erected at Jerome, Idaho, the potato storage cellar shown in Figures 1 and 18. This cellar is 30 by 50 feet, with concrete walls 8 feet in height and 8 inches thick, with a 12-inch footing. The even-span roof is of wooden-frame construction, over which is stretched heavy woven-wire netting similar to that shown in Figure 7. The netting is in turn covered with a heavy layer of straw, over which is placed a layer of soil sufficient to shed the usual rainfall of that section. Being constructed for experimental purposes, the interior arrangement, as will be noted by reference to the detailed building plan shown in Figure 19, differs somewhat from that of the usual farm potato storage cellar in that it is provided with inspection and disinfecting rooms, both of which are located at the south end of the cellar on either side of the central driveway. These rooms are practically 9 by 9 feet in actual floor dimensions and are constructed with insulated wooden walls. Each room is provided with a window and with ventilation. The disinfecting room is so constructed as to be practically air-tight, thereby permitting the use of gas fumigation if desired. The rest of the cellar is divided into eight bins, four on each side of the driveway, each approximately 10 by 10 feet. The floor of each bin is a removable one, being constructed in three sections, each section consisting of 3-inch strips of seven-eighths inch lumber spaced 1 inch apart, nailed to cleats and supported by 2 by 6 inch joists, which, in turn, rest on three 6 by 6 inch sills. The 2 by 6 inch joists were given a 1-inch shoulder on the supporting sills, thus providing a 5-inch opening into the driveway and in reality placing the ventilated board-slat floor approximately 11 inches above the earthen one. The interior face of the concrete side and end walls of the storage cellar proper is furred with 2 by 4 inch studding, spiked to the 6 by 6 inch sill below and to the rafters above. The studding is spaced 32 inches apart in the clear and is covered to a height of 6 feet with 4-inch board strips spaced 1 inch apart, as shown in Figure 13. The slatted division walls of each bin are double, constructed

in sections similar to those of the floor, and are attached at each end to the supporting posts. The cleats on which the slats are nailed, coming opposite to each other when in place, insure a 2-inch air space between the walls. This type of floor, walls, and partition construction affords a complete circulation of air around each bin, which is an important storage factor in conserving the vigor of the tubers and in lessening losses from decay. A cross section of the end elevation of this storage cellar is shown in Figure 20.

The contract price for the construction of this storage cellar, exclusive of excavation and the straw and dirt cover, but including the electric-light wiring, was $1,340. The total cost probably did not exceed $1,500. It is hardly necessary to call attention to the fact that the construction of the preparation and fumigation rooms, which would be unnecessary adjuncts to farm storage cellars, added materially to the cost of the structure. There is every reason to believe that where the grower is prepared to do most of the work himself a storage cellar 30 by 50 feet, with side and end walls of concrete and with ventilated wooden floors and interior walls could be constructed at an outlay of $700 to $1,000.

SUMMARY.

(1) Storage is employed generally for the purpose of prolonging the season of food products.

(2) The best storage temperature for table or seed potatoes is one that will keep the tubers in a dormant condition and preserve their edible quality and their vigor for seed purposes with minimum decay and moisture losses.

(3) The humidity content of the air of the storage cellar plays an important rôle in conserving moisture losses. The moisture content of the air should not be so high as to deposit a moisture film on the surface of the tuber or so low as to cause an unnecessary loss of moisture through transpiration.

(4) Thorough aeration of the stored tubers is an essential for the best preservation of seed stock and the reduction of storage losses.

(5) The exclusion of light from the storage house is an essential feature in the storage of table stock.

(6) Good storage is a vital factor in maintaining the vigor of seed stock. Its value is not yet fully recognized by the grower.

(7) The simplest form of potato storage is the pit.

(8) The next simplest form is the dugout pit or storage cellar.

(9) The third type of storage is the insulated wooden storage house, frequently found in the South.

(10) The fourth, or Maine type, is distinctively a Maine development and, aside from the artificially refrigerated house, is probably the most expensive of the types considered.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1924